Design Development of Portable Information Equipment

●Yoshihiro Ueda

As the use of computers in our daily lives becomes more widespread, there is a growing need for portable machines that can be used anytime, anywhere. Rapid progress in electrical technology has led to networking, downsizing, and dense mounting technologies that have enabled various portable information devices, such as notebook PCs, to enter practical use.

Conventionally, the design development of portable information equipment focused on the useability and the cosmetic design factors such as form and color, based on the product specifications mainly affected by technology trends. However, since there is a wide range of fully-mobile, compact portable information products, there is no de facto standard. Therefore, the design development must be geared to the users' needs and way of use, purpose, and situation, and the results must be fed back to the product specifications.

This paper explains the fundamental process of industrial design development of portable information equipment by studying the style of use. A new portable information unit called "INTERTop", which was designed using this design development process, is taken as an example.

1. Introduction

Society is becoming increasingly information dependent, and information equipment is now used as a part of daily life. The key issue in the future will be how this information is used to develop new individual values and communication. In this networked information society, information must be freely accessible from anywhere at anytime. People therefore need information equipment and information processing services that they can use wherever they may be.

Through technological innovation, the information infrastructure is being enhanced and information equipment is becoming smaller and lighter, thus enabling people to process information not only at the office but also in everyday life while on the move. Portable information equipment therefore needs to be redesigned accordingly.

2. Types of portable Information equipment and design development

There are various types of portable information equipment, each of which has different design objectives and approaches. First, we divide portable information equipment into the various types, and then review the design development of each type.

The most well-known type of portable information equipment is the notebook personal computer, which allows the user to carry a desktop computer environment outside the office. Notebook personal computers can be divided into three types according to function and performance: high-end, volume, and portable types. Portable information equipment with a small keyboard, such as Fujitsu's INTERTop, which is smaller than a compact notebook PC, is categorized as a "portable information tool." Portable innovation units with a personal information management (PIM) function, such as the electronic organizer, are cat-
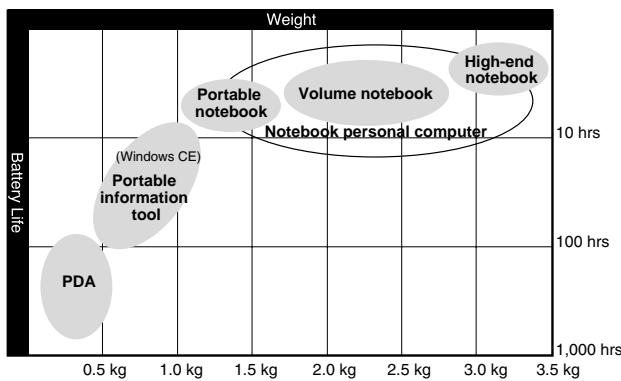
Figure 1.
Categories of portable information equipment.

egorized as personal digital assistants (PDAs). See **Figure 1.**

Since there are various types of portable information equipment, the subject and meaning of the design development differ according to the product features and product categories.

For example, a high-end notebook PC has the same function and performance level as a desktop computer, and is generally used in an office to save space rather than in a mobile environment. For this type of equipment, the focuses of the design development are, for example, the progress of the ergonomics study and the pursuit of the product identity based on the conventional configuration of a notebook PC.

A volume notebook PC has similar functions and a similar performance as a desktop computer, but takes up less space in the office and can be used in a mobile environment. When designing this type of computer, compact size and portability are important as well as good performance and product identity based on the conventional configuration.

Although the performance is slightly lower than the above two types, a portable notebook PC is smaller and lighter and is used mainly in a mobile environment. The design of this type is also based on the conventional configuration of a notebook PC, but the balance between portability and performance is the key issue. For example, the performance of the keyboard and controls (e.g.,

buttons and switches) must be maximized within the B5 or A5 size constraint, while the design and portability must be optimized for mobile use.

As stated above, the design of portable information equipment based on the configuration of notebook PCs often focuses on improving the performance and the cosmetic design (e.g., form and color) based on the product specifications mainly affected by technology trends.

On the other hand, in the portable information tool and PDA categories, there are various product characteristics in terms of function and performance. The product design is more flexible since there is no de facto standard style like that of notebook PCs. In addition, the users' information processing needs vary greatly.

When developing the portable information tool and PDA categories, the design approach should differ from that of the notebook type and must be more practical for a fully-mobile environment. Since the portable information tool and PDA categories have various characteristics with no de facto standard, the approach to users' needs and situations should be the first priority in the design development. The results should then be reflected in the product specifications.

The use environment, situation, conditions, and time should usually be researched in addition to the users' views and needs. It is important to identify the optimal product specifications according to the use, to reflect the results back on product development, and to optimize the design and useability.

3. Design development process to suit the user[1]

A five-phase design development process (**Figure 2**) is used to ensure that the design meets the users' needs by fully researching the users' circumstances. The following section describes the characteristics and method of each phase.

The first phase is brain-storming (generating hypotheses). Questions such as "What kind of personal information processing is needed in a

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fully-mobile environment?" and "Why do people use mobile computers?" are asked. Possible hypotheses are generated during this phase. In this phase, an overview of the type of usage and equipment image is developed using words and sketches.

The second phase is to examine the hypotheses. Questionnaires are drawn up and the range of subjects is decided based on the developed hypotheses. The questionnaire survey results are analyzed by statistical means, the users' information behavior and information processing needs are identified, and the validity of the hypotheses is examined. The purpose of this phase is to use research methods such as questionnaires to convert from qualitative ideas to quantitative information for the development process.

The third phase is the categorization and combination of user circumstances. Users' circumstances and behavior patterns with similar meanings are categorized and combined by analyzing

the circumstances using research data. Then, the characteristics of each circumstance (which is analyzed and combined) are in turn also combined, and the meaning and purpose of the information processing in each category is clarified.

The fourth phase is to construct the concept of the portable information equipment. Clarify which of the users' needs the equipment should support, define the basic concept of the equipment, and clarify the product request specifications. In this phase, the range and circumstances of users is set and the product image is visualized graphically and 3-dimensionally. Also, the basic requirements of the equipment development are clarified.

Visualization of the product image in the early phase is important in the design process, enabling the developers to share the requirements of the equipment as graphic images. The developers receive clear product requirements and images, and hence can precisely discuss the development work based on the same perception. The
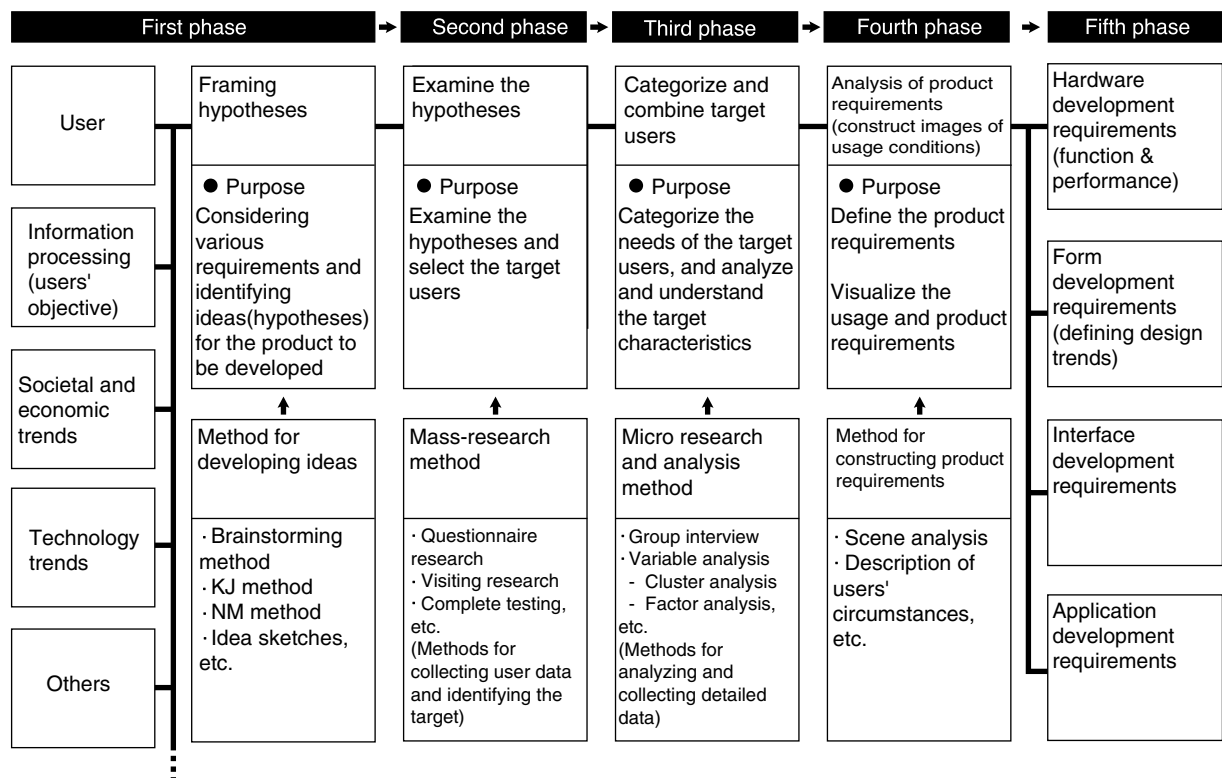

Figure 2.
Design development process based on user's circumstances.

discussion helps accurate decision-making and hence efficient development.

The fifth phase is to identify the points for technological development that are necessary in the product specifications from the graphic images of the equipment, and to conduct a detailed analysis of the users' circumstances. Technology trends are discussed to come up with the ideal image of the portable information equipment and to clarify which factors will be reflected in the product specifications and software development.

4. Design development of small portable information equipment "INTERTop"

INTERTop is designed based on this design development process to satisfy the users' needs and situation. The product specifications reflect the users' circumstances while the functions, portability, and cosmetic design have been optimized. This section introduces the design development of INTERTop as an example of the development process.

4.1 Framing hypotheses of information processing circumstances (First phase)

The first step when designing INTERTop was to imagine all the possible personal information processing circumstances on the road and in the field.

Considering the information processing needs for mobile equipment, possible circumstances were compiled using the 5W1H and brainstorming methods; for example, "What kind of personal information processing is needed?", "Why do people use mobile computers?", "Where do people need help for information processing and what kind of support do they need?", and so on. **Figure 3** shows examples of usage and gives notes explaining the hypotheses. About 30 hypotheses and various ideas of ways to support personal information processing using mobile equipment were compiled.
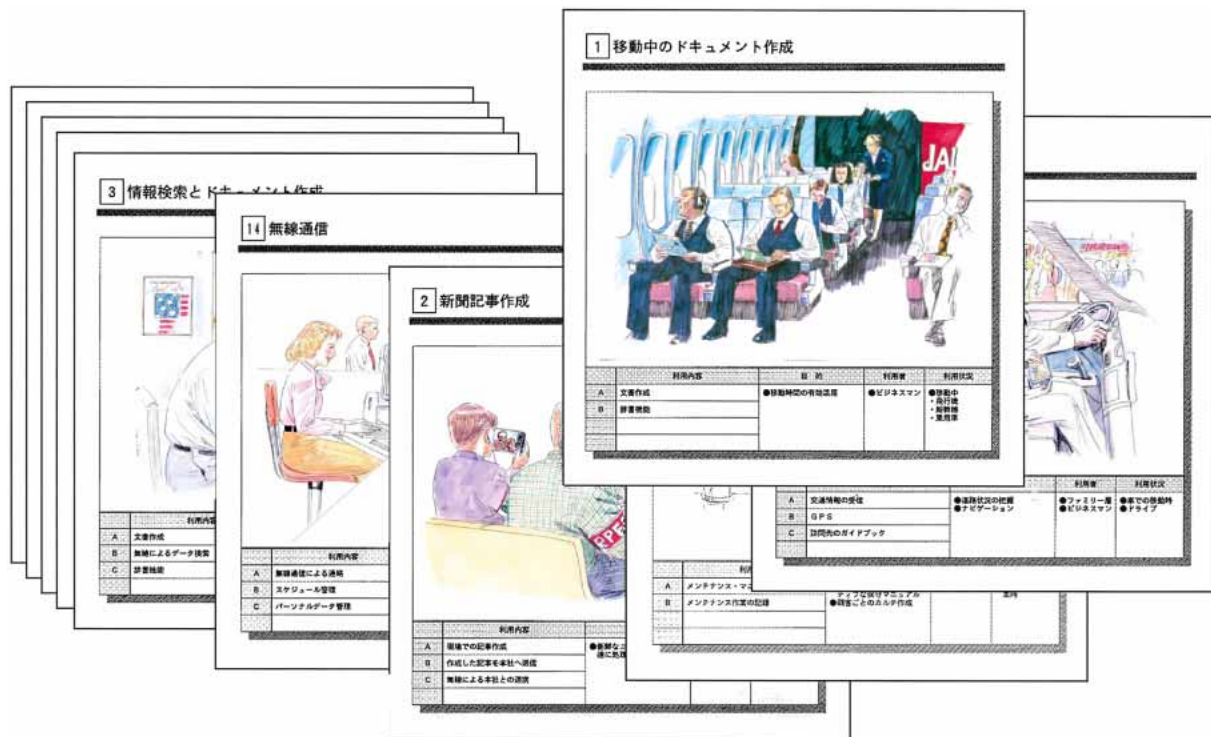

Figure 3.
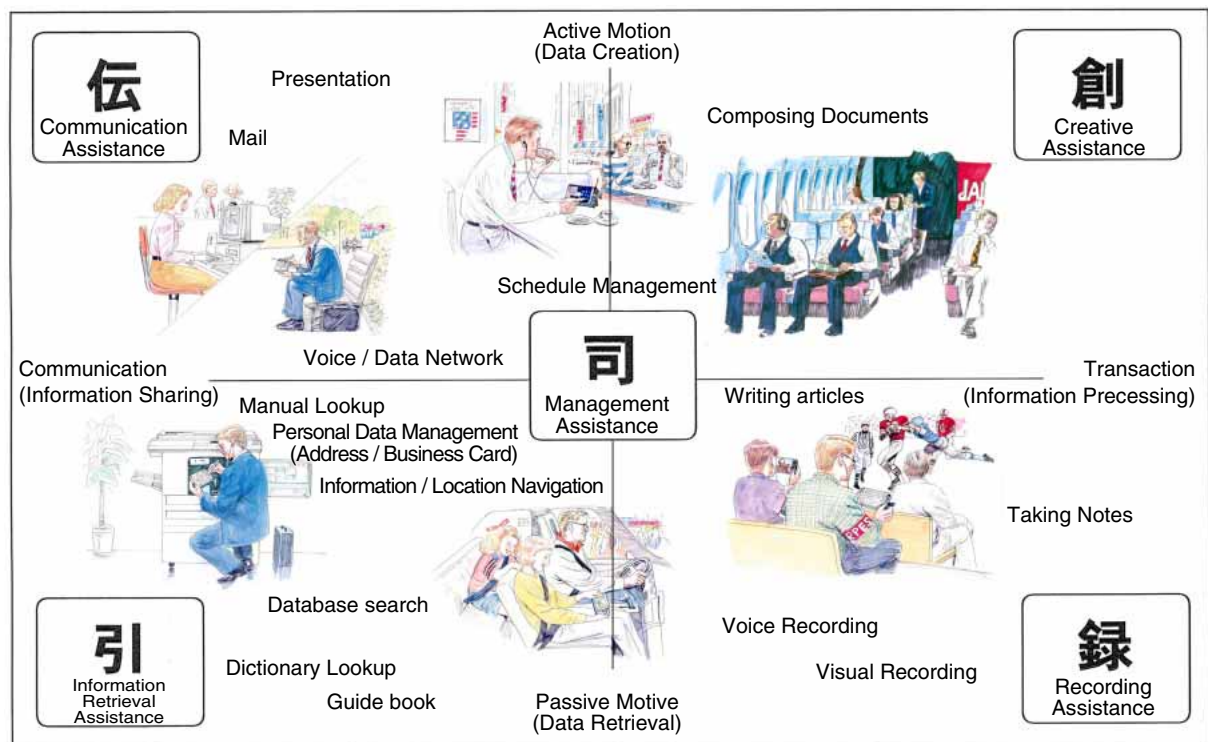Example of describing users' circumstances.
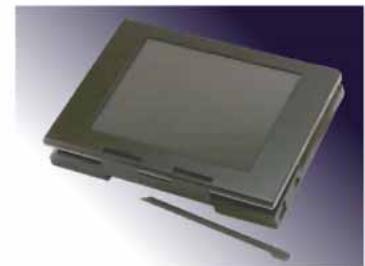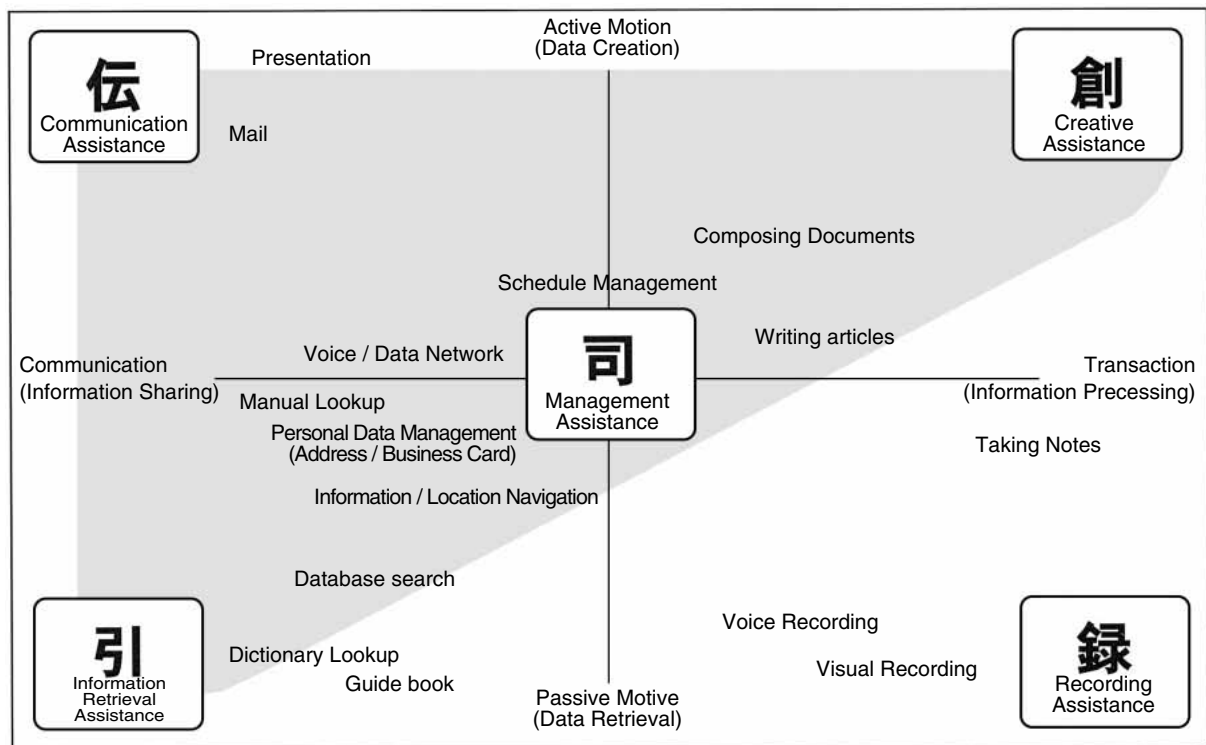
Figure 4.
Scene analysis map.

4.2 Examining hypotheses (Second phase)

The questionnaires were constructed based on the hypotheses, and the validity of the hypotheses was examined by a survey. As a result, some information processing uses were highly specific to certain user groups while others were useful mainly to business people. The hypotheses were divided into several categories in this way. Through the examination, various product requirements were identified to assist information processing circumstances, from individual daily life using mobile equipment to specific circumstances of special users. The details of this research are not given here, as we focused on phases 3 and 4 in this study.

4.3 Analyzing circumstances and drawing a map (Third phase)

The users' circumstances based on the re-search in the second phase were categorized and combined in the third phase. We considered the most effective categorization standard to define the optimal information processing involving a mobile environment, and chose two standards for the purpose of information processing and the contents of information processing. A scene analysis map was drawn based on these two standards. The horizontal axis shows the purpose of information processing. The right direction indicates emphasis on transactions, while the left one indicates emphasis on communications. The vertical axis shows the contents of information processing. The upward direction indicates active motion such as sending and creating, and the downward direction indicates passive motion such as receiving and recording. Furthermore, the circumstances of using mobile environment were mapped and then categorized and combined using the map. As

Figure 5.
Concept map and catalog of INTERTop.

a result, the following five categories were identified (**Figure 4**).

1) 創 : supporting creation, construction & composition of documents
2) 伝 : supporting communication & data communication
3) 引 : supporting searching & browsing information
4) 録 : supporting recording data of each media
5) 司 : supporting management of personal in formation

These categories can be used as the core categories for developing any portable information equipment. This map shows the key issues for constructing the concept of a mobile environment.

4.4 Defining the basic concepts and requirements of INTERTop (Fourth and Fifth phases)

Using the analysis map of the third phase, the basic concepts and requirements of INTER-Top were studied and reflected in the product specifications.

To identify the basic concepts of INTERTop, the categories to be supported were discussed using the analysis map. The basic concepts of INTERTop are that it is a mobile communication device that supports 創, 伝, 引 and 司 (**Figure 5**).

Next, the information processing circumstances for each category, 創, 伝, 引 and 司, were analyzed in detail and the important features were studied to define the users' values. The product specifications of INTERTop were constructed based on these studies, and the objective of design development was fixed.

For example, to meet the needs in 創, a keyboard large enough for touch typing and an easy-to-use editing program are required. Communication functions such as image browsing for portability, referencing, and searching for Inter-

I n p u t : Touch panel
Handwriting recognition
Speech recognition (command / data input)

D i s p l a y : DSTN color LCD
239 × 168-dot / 256 colors

V o i c e : Artificial voice (reading of selected information)
Voiceprint recognition and smart card function
(Authorization / personal security)

Communication: High-speed digital data mobile communication
Radio / beep / portable telephone combination
(all-in-one)
Infrared communication /
network function combination

P o w e r : Alkaline dry battery (AAA) × 2
Lithium ion battery
Battery life approx. 100 hours

Dimensions: 156 (D) × 98 (W) × 23 (H) (pocket size) /
Approx. 300g

O t h e r s : Multi-card (PCMCIA)
High-speed memory path (RAMBUS)

Figure 6.
Concept catalog of viewer type electronic organizer.

net information, electronic mail, and network access are needed to meet the needs in 伝 and 引. In addition, a PIM function is needed to satisfy the requirements of the 司 category.

The target users were assumed to be business people making many business trips and busy managers. The common needs of these users are mainly good portability; the communicator must be easy to carry, and so should be smaller and lighter than the existing A5 size. The relationship between portability and performance was carefully studied from the users' perspective. Consequently, the minimum of A5 size and 600 g weight were set as development objectives to ensure a good balance between portability and functionality.

The other common needs of users are easy-to-use functions and a good human interface for those operations that users expect of information terminals; the device is only useful if it is easy to use. Also, for users who often work with images, a new input method using a pencil and handwriting recognition was highly desirable, so the development considered convenient input using both keyboard and pencil.

From the analysis of users' circumstances, we found that people would carry the INTERTop in various ways, such as in a bag or purse, or in the hand. Therefore, an important factor in the design of the INTERTop was to balance strength and fashionable design to create an attractive personal tool.

This analysis map is useful for developing various concepts of portable information equipment. For instance, if a portable device supports the 引 and 司 categories, a viewer-type PDA will be identified (**Figure 6**), while a "multimedia notebook" PC will result for portable informa-
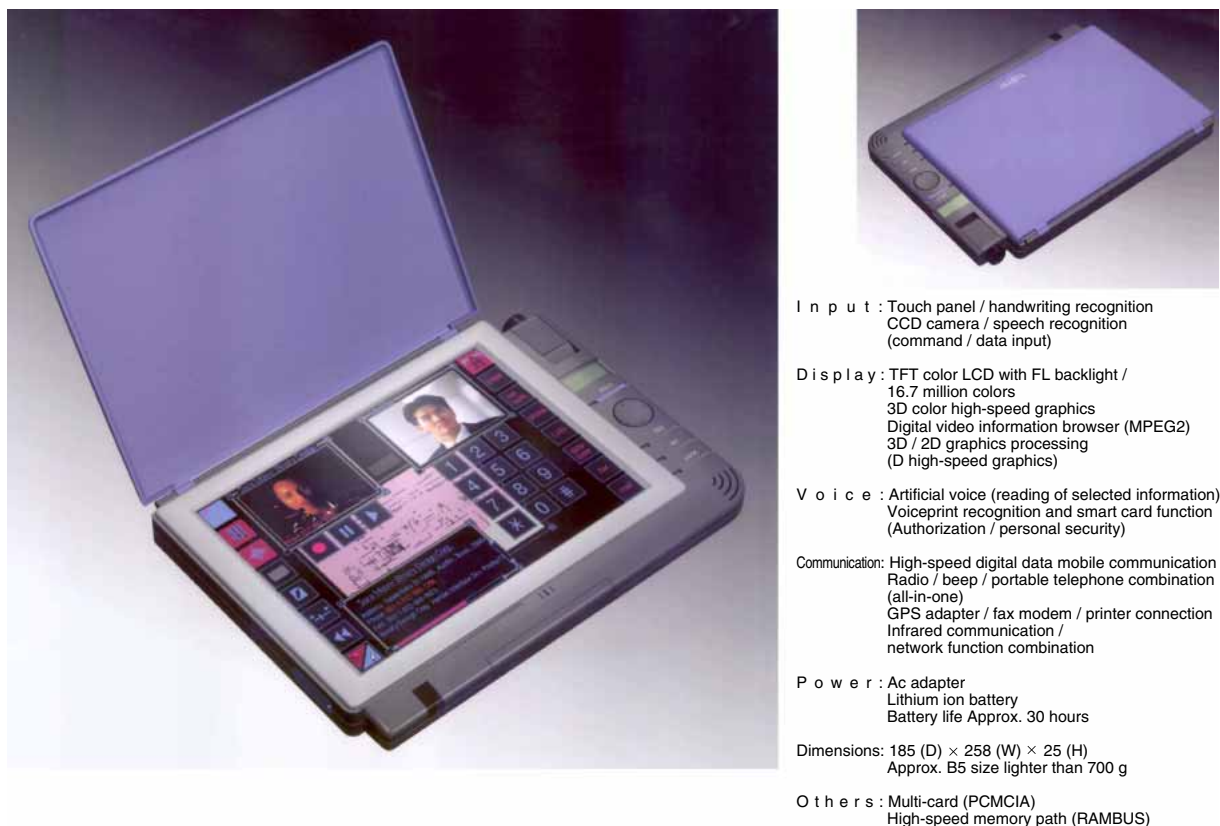

I n p u t : Touch panel / handwriting recognition
CCD camera / speech recognition
(command / data input)

D i s p l a y : TFT color LCD with FL backlight /
16.7 million colors
3D color high-speed graphics
Digital video information browser (MPEG2)
3D / 2D graphics processing
(D high-speed graphics)

V o i c e : Artificial voice (reading of selected information)
Voiceprint recognition and smart card function
(Authorization / personal security)

Communication: High-speed digital data mobile communication
Radio / beep / portable telephone combination
(all-in-one)
GPS adapter / fax modem / printer connection
Infrared communication /
network function combination

P o w e r : Ac adapter
Lithium ion battery
Battery life Approx. 30 hours

Dimensions: 185 (D) × 258 (W) × 25 (H)
Approx. B5 size lighter than 700 g

O t h e r s : Multi-card (PCMCIA)
High-speed memory path (RAMBUS)

Figure 7.
Concept catalog of multimedia notebook.

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tion equipment supporting 伝, 録, 引 and 司 (**Figure 7**).

5. Characteristics of INTERTop and new technology

Through the above processes, INTERTop was designed with four significant characteristics compared to other existing portable information equipment. These characteristics and the new technologies which made them achievable are briefly explained below[2].

5.1 Good portability of communicator & editor

The basic specifications of INTERTop were a small, light, portable information terminal for using and sending information through the Internet. The functions focused on communications such as sending and receiving electronic mail and browsing the Internet, so a 7.2-inch color VGA screen was chosen (**Figure 8**). To allow simple documents such as mail and notes to be composed, a keyboard was mounted for touch typing and editing. Meanwhile, to ensure good portability, the components and functions were carefully selected; the latest technologies were installed; and strong, light materials were used. As a result, the portable communicator is small and light at just A5 size and 750 g.

5.2 Small keyboard for touch typing

The ergonomics were analyzed during development to solve the following issues: "How can an A5 keyboard be used for easy composition?" and "What is the smallest key pitch that allows touch typing?" Several prototypes were developed, and after experiments on ease of use, a mini keyboard was developed with a 15-millimeter key pitch for the INTERTop (**Figure 9**).

5.3 360-degree rotating hinge

A 360-degree rotating liquid crystal panel was mounted to allow pencil input for the INTERTop. This design meets users' needs and situations such as various input functions and flexibility to make the best of INTERTop's functions. The device optimally combines two types of PC, the notebook and pencil input types, for maximum usefulness. This design, with a 360-degree rotating hinge, will likely lead to new uses (**Figure 10**).

5.4 Aluminum alloy housing

To make INTERTop a handy, portable individ-

Figure 8.
INTERTop design for communicator & editor.

Figure 9.
7.2-inch color VGA screen and 15-millimeter key pitch keyboard.

Figure 10.
360-degree rotating hinge.

Figure 11.
Aluminum alloy housing.

ual tool, a new housing material and housing processing technique were chosen. An aluminum alloy was selected as the housing material behind the liquid crystal screen of INTERTop to satisfy the design requirements of a good grip, light look, and strong housing. This was Fujitsu's first use of this new material. The characteristics of this material allowed a strong, fashionable housing to be designed with many color variations (**Figure 11**).

6. Conclusion

INTERTop has revolutionized the image of portable information equipment, changing it from the typical notebook computer image to a stylish personal tool. The outstanding design quality of INTERTop has been acclaimed throughout the world, winning the Good Design Award in Japan and Red Point Award in Germany. These achievements were made possible by user-oriented devel-

opment based on research of users' circumstances and compromise-free design.

In addition, the design process based on users' needs and situations can be applied to other product categories. For example, new product categories such as family type PCs will be increasingly important in development processes. This study has proposed a product development method based on the users' perspective. In the future, we shall execute design development focused on user in order to create attractive products.

References

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2) Ueda, Y. et al. : Good Design of Portable Information Equipment. *M & E International Technology Magazine*, Industrial Study Group, **25**, 2, pp.172-178 (February 1998).

Yoshihiro Ueda received the B.E. degree in Industrial Design from Kyushu Institute of Design in 1980. He joined Fujitsu Ltd. in 1980 and has been engaged in design development of various new fields such as space design, ergonomics design, advanced design, and product design of personal information equipment.